ENAMELS

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PROSPECTS OF USING DIATOMITE MATERIAL FROM THE SVERDLOVSK REGION IN ENAMELLING PRODUCTION

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Natural diatomite rocks are investigated. Their structure, mineralogical specifics, chemical composition, and phase transformation under thermal treatment are considered. It is demonstrated that diatomite rock is a promising material for enameling production.

Diatomite rock is a loose, earthy or loosely cemented porous and lightweight rock of sedimentary origin, mainly formed by fragments of armor (skeletons) of diatom algae: diatomea and radiolaria. Diatomite is a microscopic single-cell diatom alga whose size ranges from 0.75 to 1500 μm; sometimes this rock is called infusorial earth, kieselghur, or mountain meal. The main components of the siliceous armor are silica hydrates of a different degree of water content (opals) $SiO_2 \cdot nH_2O$. Diatomite rock belongs to the group of silica-bearing materials. It analysis for the purpose of using it in the production of enamel frits is of interest in the context of the integrated application of local mineral materials and also in view of nsufficient knowledge of its technological properties.

The Sverdlovsk Region has substantial resources of silica-bearing materials in the form of diatomite, tripolite, and opoka bedded at a small depth.

We have investigated natural rock samples from the quarries of the Irbitskii and Kamyshlovskii Building Material Works. We have studied the structure, mineralogical specifics, and phase transformation in these rocks under thermal treatment ranging from room temperature to the melting point.

Irbitskii diatomite is a yellowish-gray and Kamyshlovskii is a greenish-gray sedimentary rock whose main component is amorphous SiO_2 (70 – 80%). The study of the physicomechanical properties of these rocks yielded the following data: their volume weight in lumps is within 500 – 700 kg/m^3, their porosity varies from 80 to 90%, the natural moisture is 7 – 10%, their milling fineness (residue on a No. 008 sieve) is 9 – 10%, and their specific surface area is 3800 cm^2/g, which corresponds to a finely dispersed lightweight porous structure.

A study of the granulometric composition of diatomite shows that the dustlike fraction (particle size 0.060 – 0.005 mm) has up to 75% particles and the content of the sand fraction (particle size 1.00 – 0.06 mm) is around 20%, and that of the argillaceous fraction (particle size below 0.005 mm) is around 5%. Based on these data, the diatomites considered can be attributed to the group of silty sandy loam, according to Okhotin's classification.

To determine the mineral composition of Irbitskii diatomite rock, we performed x-ray phase analysis. A halo was identified in the range of small and medium angles, which points to a high degree of amorphousness of the main components of the rock. This conclusion is corroborated by the shape of the diffraction reflections; they have a blurred maximum and in some cases the half-width of a reflection is commensurate with its height. The main crystal phase is β-quartz, whose crystal lattice has the following typical diffraction reflections (d = 0.443, 0.034, and 0.181 nm).

The average composition of the considered rocks obtained by their chemical analysis is presented in Table 1.

To study the specifics of the phase and structural transformations of diatomite rock in heat treatment, differential thermal analysis was carried out. Under heating in the temperature interval of 100 – 200°C we observed an endothermic maximum, which in Irbitskii diatomite corresponds to 180°C and in Kamyshlovskii diatomite to 150°C. This endothermic effect is related to the removal of the major part of adsorption water and part of the interpack water from the argillaceous mineral. Under further heating, we observed endothermic effects at temperatures of 610 – 800°C for Irbitskii

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TABLE 1

Diatomite	Weight content, %							
	SiO_2	CaO	MgO	Al_2O_3	$K_2O + Na_2O$	Fe_2O_3	TiO_2	calcination loss
Irbitskii	72.00	0.95	1.36	8.20	2.10	3.92	0.40	13.07
Kamyshlovskii	75.40	1.90	0.80	9.00	2.20	4.10	–	6.60

diatomite and at 652 – 740°C for Kamyshlovskii diatomite, which are caused by the phase transition of β-quartz to α-quartz and the loss of crystallization water from montmorillonite. The weight loss in samples calcined to 1000°C was equal to 8 – 10%, which corroborated the presence of the argillaceous component. It can be assumed that aluminum and iron oxides are fixed in natural hydrate compounds of the $R_2O_3 \cdot nH_2O$ type.

The analysis of the chemical, granulometric, and mineral composition of the considered rocks corroborates the good prospects for their application as aluminosilicate materials for producing vitreous enamel frits. The high content of iron oxide in diatomite rock is responsible for its intense coloring; therefore, this rocks can be mainly used for dark-colored undercoat enamels.

The amorphous forms of silica contained in diatomite, including silica hydrates, dissolve well in alkalis and are significantly more chemically active than quartz. The high activity of diatomite is caused by the adsorption of carbonate hydrates of alkalis and alkaline-earth metals on the extended amorphous surface of the mineral phases of diatomite, which make it possible to intensify the sintering and melting processes in the enamel frit mixture.

Thus, diatomite rock can be a source of silicate-bearing material for enameling production. The presence of iron oxides in diatomite rocks enables using them to develop vitreous enamel coatings with a high strength of adhesion to metal and a wide color range, without additionally introducing pigments or adhesion oxides.